Appendix 3-5

Compressor Cost Estimate

Compressor Stations Cost Estimate

The capital costs for the compressor stations for engineering analysis were estimated as the sum of individual costs developed as described below.

Gas compression

Itemized costs for the Taurus 60, Taurus 70, Mars 100 and Titan 130 model turbine compressor sets manufactured by Solar were available in the ANGDA information. It was assumed that a single turbine generator set would be installed at each station.

After cooling

Natural gas heats when it is compressed. Generally, the pipeline will be operated at temperatures above 32 degrees Fahrenheit through areas where the permafrost is not present or present along a relatively small portion of the alignment. It was assumed that fan type coolers would be installed where the gas discharge temperature from a station would otherwise exceed 100 degrees F. It was assumed that the coolers would be sized to lower the gas temperature to 30 degrees F above the local summer ambient air temperature.

The need for after-cooling generally occurred with scenarios involving unrealistically high flow rates and large numbers of compressor stations. Construction of scenarios requiring after-cooling was considered unlikely and capital cost were for after-coolers were roughly estimated at 50 percent of the cost for gas compression regardless of the cooling duty.

Spare turbine compressor set

Aero-derivative turbine driven compressors such as the Solar equipment can be quickly exchanged with an off-line spare for scheduled or unscheduled maintenance. The equipment costs, excluding installation, for one additional turbine generator set was assigned to the first compressor station to account for a system-wide spare unit.

Refrigeration

It was assumed that a closed loop propane refrigeration system would be used to cool the gas at the discharge of compressor stations located in permafrost in order to return the gas to pipeline at a temperature of 30 degrees F. The refrigeration system consists of the refrigerant evaporator, compressor, condenser and associated valves and piping (Section **Error! Reference source not found.**). The capital costs for the refrigeration system were estimated on a station-by-station basis using a cost factor referenced to the horsepower of the refrigerant compressor determined via hydraulic simulation.

The load on the refrigeration system will vary with seasonal gas flow, seasonal climatic conditions, and the pipeline operating profiles. The loads refrigerant equipment will tend to be greater during the summer than during the winter due to warmer summer ground and ambient air temperatures. The J-curves are based on simulations of summer pipeline operation in order to address the cost of refrigeration.

The capital costs of the propane refrigerant systems were estimated by:

1) Estimating the operating horsepower of the refrigerant compressor on a station-by-station basis;

2) Estimating the installed refrigerant horsepower by adjusting the operating refrigerant horsepower by

   Gear box losses (assumed direct drive so no gear box loss),

   Turbine driver power loss due to pressure drop in the turbine air intake,

   Turbine driver power loss due to pressure drop in the exhaust system,

   Non-recoverable power losses due to turbine aging,

   Recoverable turbine loss between turbine cleaning,

   De-rating turbine power due to elevation, and

   De-rating turbine power due to ambient air temperature;

3) Applying the refrigerant capital cost factor of $2,121 per installed horsepower (Appendix C).

The refrigerant system must be designed to accommodate both summer and winter operation, accounting for seasonal changes in a number of operating conditions. Completion of detailed thermal-hydraulic analyses required to determine seasonal operation of refrigeration equipment it outside the scope of work for this study and is not necessary for comparison of the relative economic merits of pipeline and station scenarios.

General station costs

A certain amount of station equipment is essentially independent of the size of the compression and refrigeration installed at the station. These costs include fuel gas conditioning, SCADA and communications, pig receivers and launchers, control room, temporary living quarters, storage and site grading.

The costs for the pig receiver, pig launcher and station bypass valve are based on a 24-inch pipeline with an operating pressure of 2,500 psig. These costs reflect a small portion of total station costs and were used for all pipeline scenarios without adjustment for pipe diameters or operating pressure.

Heater station

Simulation of winter operation was completed for a select number of pipeline and station configurations. It was assumed that water bath heaters would be installed at locations where gas temperature during the winter would otherwise drop to below 15 degrees F. The thermal-hydraulic simulations required to address the need and size of heaters is outside the scope of this study. A rough estimate of $5million was assumed for installation of an entire heater station.

Total station costs

The total station costs are the sum of the gas turbine compressor costs, cost for a system-wide spare turbine compressor, refrigeration costs and general station costs. A summary of these costs is shown in Table # 0.1.

Table # 0.1: Summary of Compressor Station Costs

	Taurus 60	Taurus 70	Mars 100	Titan 130
ISO turbine horsepower	7,700	10,300	15,000	20,000
Turbine compressor set ($mm)	$5.14	$5.63	$8.74	$9.24

After cooling ($mm)	$2.57	$2.82	$4.37	$4.62
Spare turbine compressor ($mm)	$4.23	$4.72	$7.45	$7.95
Refrigeration ($ per installed horsepower of refrigerant compression)	2,121	2,121	2,121	2,121
General station ($mm)	$22.55	$22.55	$22.55	$22.55

Schedule of capital outlays

It was assumed that compressor stations would be constructed over a two-year period with 40 percent of the capital outlays expended two years prior to start-up with the 60 percent balance expended in the year prior to start-up. Procurement costs were included in the two-year construction cost outlay schedule. In practice a small portion of procurement costs would occur prior to station construction. The costs for detailed engineering of the compressor stations are included in the engineering costs for the pipeline.

Compressor Station Operating Costs

Annual non-fuel station operating expenses were estimated based on public data contained in a pipeline study prepared for ANGDA by Baker in 2005 and Enstar's experience regarding operating of gas compressors in the Cook Inlet regions. Non-fuel operating costs for were estimated at 3.5 percent of the installed capital in the 2005 ANGDA work. Enstar's suggested a cost slightly greater than 3.5 percent of installed capital. Non-fuel operating costs were estimated at 5.0 percent of installed capital the purposes of J-curve analyses.

The volume of gas delivered at the pipeline terminus is reduced by the cumulative fuel consumption of all station along the pipeline. Fuel expense is accounted for by simply selling less gas on a thermal basis than is purchased. The compressor fuel is valued at the gas purchase price at the pipeline inlet.

Escalation of Station Costs from $2005 to $2006

The basis for the capital expense estimates for the compressor stations is $2005. The station capital costs were escalated at 2.5% per year to express the costs in future year dollars.